The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

JUNE, 1886.

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By faith we understand that the worlds have been framed by the word of God, so that which is seen hath not been made out of things which do appear.

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CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

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DESCRIPTION OF A PRINTING CHRONOGRAPH.

PROF. G. W. HOUGH, DIRECTOR OF DEARBORN OBSERVATORY.

About the year 1848, the idea of recording astronomical observations, by the use of galvanic electricity, was put in successful operation by different individuals. Since that time chronographs of various forms have been constructed for recording in a legible manner, on a moving sheet of paper, the time of any phenomenon observed. The great superiority, in point of accuracy and saving of labor over the old eye and ear method, formerly used, soon led to the general adoption of the new plan.

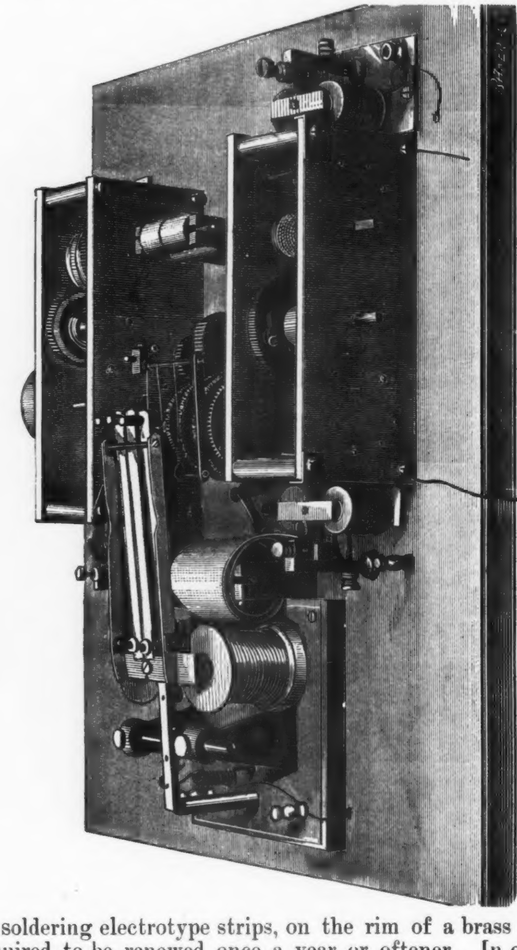
The idea that type-wheels might be substituted for the moving paper, and a printed record made, was long ago entertained by astronomers, and various plans were devised for accomplishing this purpose.

In the year 1865, in a paper read before the Albany Institute, I gave an outline of a plan for a printing chronograph, radically different from any that had been proposed. It was based on the principle of using separate systems of mechanism for the fast running type-wheel, and those recording the integer minutes and seconds. These two trains to be simultaneously controlled by the sidereal clock, and to be entirely independent of each other.

In the year 1871 I completed a printing chronograph based on this method.

This machine was in constant use at the Dudley observatory for three years, demonstrating the practicability of such an apparatus.

In this first machine the blow for printing was done by a hammer, elevated by a heavy train of clock-work, which made the instrument somewhat unwieldy. The type-wheels were constructed



PROF. G. W. HOUGH'S PRINTING CHRONOGRAPH.

by soldering electrotype strips, on the rim of a brass disc, and required to be renewed once a year or oftener. In other respects the machine was entirely satisfactory.

About a year ago, I put in operation at the Dearborn observatory the printing chronograph about to be described. Since the machine was first set up, the mechanism has been modified in various ways in order to bring the instrument in as compact and convenient a form as possible.

The accompaying wood-cut will aid in making a description of the machine intelligible. The relative size of the different parts may be inferred from the statement that all the mechanism rests on a table eighteen inches by twenty-four inches.

First, the movement in the rear, consists of a system of clock-work, carrying a type-wheel with fifty numbers on its rim, revolving once every second; one, two, or parts of two numbers being always printed, so that hundredths of seconds may be indicated.

This train is primarily regulated to move uniformly by the Frauenhaufer friction balls, and secondarily by an electro-magnet acting on the fast moving type-wheel and controlled by the sidereal clock. This train is entirely independent, and can be stopped at pleasure, without interfering with the other type-wheels.

Second, the movement in front consists of four shafts for carrying the type-wheels indicating the minutes and seconds. The motion of this train is also governed by an electro-magnet, controlled by the sidereal clock, operating an escapement in a manner analogous to the action of an ordinary clock; every motion of the escapement indicating integer seconds, advancing the type one number. There are three type-wheels, indicating minutes, seconds and hundredths of seconds. The integer seconds are advanced at every oscillation of the standard pendulum; and the minute, at the end of each complete revolution of the seconds' wheel.

The type were cut on solid cast-brass discs, and will probably wear as long as other parts of the mechanism.

Third, in the right hand end of the front movement there are three shafts, for moving the paper fillet, on which the record is made.

The large electro-magnet operating the printing hammer is seen on the left, directly under the hammer-arms is the spool

of paper. When the machine is ready for use the end of the paper is drawn over the tops of the type-wheels, and passed between the brass rollers between the two movements.

The train for moving the paper is unlocked by an electro-magnet whenever an impression is made, or it may also be unlocked independently by a duplicate observing key so as to leave a blank space of any desired amount between the records for different stars or groups of wires.

The paper fillet is two inches in width, and the spool will hold about forty feet — sufficient for 1200 observations, including the spacing for different objects.

The type are inked by means of small rollers covered with cloth, resting against their rim, and revolving with the wheel by friction. These rollers require inking every two or three days. The inking rollers, however, may be dispensed with and impression ribbon used instead, but it is not nearly so handy, and besides requires a heavier blow to get a good impression.

The blow for making the impression is struck by means of the electro-magnets of one ohm resistance. The hammer-arms are flexible. When the armature is pressed down without striking a blow, the hammers stand about one-half inch above the type. The impression is therefore made from the spring of the arms and not by a direct blow.

By this device, which is regarded of the greatest importance, the motion of the type-wheel is not disturbed an appreciable amount. None of the type-wheels are stopped in the act of printing.

If the record is made while the type-wheel indicating integer seconds is in the act of escaping, two numbers, or one number and part of another, is printed, so there is no ambiguity; this condition, of course, only occurs when the hundredths of seconds' wheel indicates 0.96 to 0.02 seconds. If two integer seconds are printed when, for example, the hundredths read 0.98 the smaller number is the correct one.

The battery for operating the printing magnet consists of three storage cells, charged in series, by means of eight gravity

elements. The charging battery is kept permanently connected with the storage cells. By means of this compound battery, there is always sufficient current to operate the recording and printing chronographs, at the same time— as well as an electric bell — in all eight pairs of electro magnets.

The storage cells each consists of two lead plates, four by six inches, coated with red lead, and hung vertically in a glass jar, containing dilute sulphuric acid. The lead plates may be kept in constant use for one year without renewal.

Aside from the printing magnet, the electrical power required is essentially the same as for a recording chronograph.

The printing magnet might be operated with three Grove cells or their equivalent.

The machine is readily set to indicate the time given by the clock's face.

The hundredths-of-seconds wheel needs no adjustment as it is permanently set to print zero, when the connection is made by the clock pendulum.

The integer seconds are set with the clock by rapidly operating the escapement by hand; and the minute wheel may be moved in either direction.

It requires about two minutes to get ready for observing, including the preparation of the inking rollers.

In observing some stars with our first machine, it was found advantageous to set the type to print directly the nearest integer seconds of mean right ascension so that the final reduction was always a small quantity.

During the construction of the present machine, a great many experiments were made to ascertain the probable error due to our method of control. For this purpose the standard mean time signal clock was arranged to operate the printing magnet once each minute. By this means the comparison between the sidereal and M. T. clocks was made for every part of the second. The difference between two successive records and 0.164 second gave the errors of any impression.

By employing an ordinary train (similar to that used in a cheap clock) for driving the hundredths-of-seconds' wheel, the "mean" error was about ± 0.03 second, and the maximum possible error ± 0.08. This train was so imperfect that it was necessary to make it gain 0.20 second in every second in order to carry it over the hard places. The train now used, is ordinary gear, accurately cut but not polished. The "mean" error is found to be ± 0.015 second with a possible maximum error ± 0.05 second.

In order to secure the best possible results, the train for driving the hundredths-of-seconds' type-wheel should be as accurately constructed as that used for an astronomical clock, then the "mean" error would be less than ± 0.01 second and the maximum possible error would not exceed ± 0.03 second.

The theory of control, for securing hundredths of seconds, is as follows: A train of clock-work is regulated, by any suitable device to run with approximately uniform velocity, but always a little fast; the final control is then secured by an electro-magnet, checking its velocity once every second. The whole train may be checked, or only the type-wheel shaft, the latter being driven by friction.

By employing the first method the probable error of any impression is a little less than for the latter.

When the whole train is regulated, however, and it is stopped by design, it may require several seconds for the type-wheel to come in coincidence with the sidereal clock, whereas when the type-wheel shaft is driven by friction only, the coincidence will be secured in one or two seconds.

The train for carrying the integer minutes and seconds' type, will run about ten hours, without winding, requiring a weight of seven pounds, single cord. The train for running the paper fillet requires about two pounds weight, single cord. The train for hundredths of seconds will run one hour and forty minutes and requires a weight of fourteen pounds, single cord.

The saving of time and labor by the use of a printing chronograph is very considerable.

In an observatory when systematic meridian work is done, the saving in labor for a single year, would probably amount to more than the cost of the machine.

THE STATIONARY METEOR SHOWERS.

W. F. DENNING, BRISTOL, ENGLAND.

For The Messenger.

Before proceeding to quote facts bearing on the stationary radiation of meteors, I wish to refer to the interesting remarks of Mr. S. J. CORRIGAN in the MESSENGER for April, 1886.

The mathematical treatment of the question by your able correspondent does not effectually dispose of the difficulty or clear up the mystery involving it. If, as assumed, parabolic orbits are truly representative of the meteors forming these alleged stationary radiants, then such meteors (encountering the *Earth* on widely different dates) must necessarily exhibit, as he proves, a very great dissimilarity of orbit and can have no physical correlations. For the date (= node) is of equal importance with the radiant and parabolic meteors emanating from the same apparent focus on the star sphere at different epochs, possess no affinity other than a mere coincidence in their observed directions. If parabolic motion is really applicable to the bulk of visible meteors, then the idea of stationary radiation is not tenable for a moment. But the general adoption of a parabola in computations of meteoric orbits is based on an assumption. There are large discordances and errors in estimating the *durations* of meteor flights and the form of orbit, which is inferred from this, is also open to very grave doubt.

In the instance of the special showers from near ε *Persei*, R. A. 61.°8, Dec. 36.°8+, quoted by Mr. CORRIGAN as a case in point, the observations of the meteors of 1872, August 10, and 1869, November 6, are very uncertain as to this important feature of duration. The time of flight for the former was roughly estimated by one observer only as 0.5 second, but in the latter

case there is still great reason for doubt. Prof. Herschel adopted 5 seconds as the probable observed velocity from a mean of two observers who gave 4 and 6 seconds respectively; but there is strong evidence this is much overrated. Mr. J. Chapman at Broadstairs in Kent observed the fireball and alludes to "its very rapid motion," adding, "the whole scarcely occupied 2 seconds." Mr. T. Humphrey, at Hawkhurst, remarks: "I particularly noticed the extreme rapidity of the meteor's flight. My own description of the meteor as seen at Bristol was that "it glided swiftly down the sky" and "its duration could not have exceeded 2 seconds." I remember this fireball well. It descended with great suddenness, flashing out at the end point with marvellous brilliancy and projecting a *vivid* streak near η *Serpentis* for fully fifteen minutes. From these and other accounts its visible duration of flight must have been nearer *one* than *five* seconds. Were the latter accurate the meteor would have fallen *very slowly*, whereas several of the observers concur in their expressions as to its extreme swiftness. The length of course in the atmosphere traversed by this body being about 175 miles, its real velocity was probably more like 100 miles per second, than the 26 miles per second which a parabolic orbit gives. These facts destroy the weight of the comparisons made by Mr. Corrigan on the basis of a parabola, the observed rate of motion being quite inconsistent with that form of orbit. It is most unfortunate that the durations of meteors cannot be estimated (unless in exceptional instances) within small limits of error, and that no plan seems available to insure greater accuracy.

I will now proceed to state some facts bearing on stationary radiants. When, ten years ago, I began habitually recording meteors, I found a number of showers in lingering activity for several months. Further observations only confirmed the idea and multiplied the cases of such persistency. I then made a special effort to trace whether the radiant points of each of these continuous showers remained absolutely stationary, or

whether, the successive displays showed displacement such as must naturally occur in systems grouped together by mere chance. I ultimately found that such displacements as were apparent merely resulted from unavoidable errors of observation and that allowing for these, the places of radiation become fixed points in the firmament. Certain regions were vacant of showers,while other points again and again became the well defined centers of convergence. Not satisfied with my prior results and realizing the serious theoretical impediments to their adoption, I instituted another series of observations, but utterly failed to shake my former convictions. My paper, printed in the *Monthly Notices* for December 1884, contained the more prominent facts observed in relation to the stationary showers and since that was written I have again practically tested the question. From 1334 meteors (omitting *Perseids* of August 10 and *Andromedes* of November 27) which I observed with the utmost care during the last 9 months of 1885 I found additional corroboration of the long-enduring streams. It is unnecessary for me to quote many details here, but I adduce a few conspicuous examples of these presumably stationary showers with the hope that they will form the materials for rigorous criticism and discussion and that some light may be thrown on the question.

Since my results were published in December 1884, I have carefully sifted and in part revised my observations. I have also added others and derived the radiant points either from the records of a single night, or from very limited periods as Colonel Tupman once stated, that fixed radiation would disappear under such treatment. The sequel proves however that it becomes more strikingly evident. For the present I only summarize five series of positions relying solely upon my own observations.

I. NEAR MU PERSEI.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1878 July 26, 27 and 30	59°	+47°	slowish.
1877 August 12	60	+50	swift, streaks.
1877 August 16	61	+48	swift, streaks.
1879 August 22	61	+50	swift, streaks.
1885 September 5	61	+49	swift.
1877 September 7	61	+48	swift.
1877 September 15	61	+48	swift.
1879 September 21	61	+48	swift.
1884 September 22	59	+49	very swift.
1877 October 8	61	+47	very swift.
1877 October 17	62	+48	swift.
1877 November 4	61	+49	swift.
1879 November 14	59	+48	swift.
1885 November 30	60	+49	very swift.

In January 2, 1886, I observed several *very swift* meteors from 62° +47°, but clouds came over before I could secure sufficient paths to accept the radiant with perfect safety. The remarkable facts in connection with this recurring shower are the nearly identical positions of its radiant and the great and sustained velocity of the meteors. Parabolic elements will not satisfy the very swift motions observed at the end of November and also probably in Jauuary.

II. NEAR EPSILON PERSEI.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1879 August 21, 22, 23 and 25	62°	+35°	very swift, streaks.
1884 August 25	62	+37	swift, streaks.
1885 September 3	62	+37	swift, streaks.
1877 / 1885 } September 5	60	+35	swift, streaks.
1880 September 6	61	+36	swift, streaks.
1877 September 7	60	+38	swift, streaks.
1885 September 8, 9 and 10	62	+36	swift, streaks.
1877 September 15 and 16	61	+36	swift, streaks.
1885 September 17	62	+38	swift, streaks.
1879 September 20 and 21	61	+38	swift, streaks.

I have not seen this radiant well-defined in October though both in November and December it apparently resumes a marked activity. On November 4, 1877 it formed a conspicuous shower.

During the month from August 21 to September 21 the display is a notable one, and furnishes many brilliant meteors of the swift streak-bearing class similarly to the *Perseids* of August 10.

III. NEAR BETA TRIANGULI.

EPOCH.	RADIANT. R. A.	RADIANT. Dec.	VELOCITY.
1878 July 27	28°	+36°	swift, streaks.
1879 July 29	30	+37	swift, streaks.
1877 August 4	30	+37	swift.
1884 August 25	30	+36½	swift, streaks.
1879 September 15	30	+36	slowish.
1879 September 21	30	+36	slowish, long paths.
1877 October 8	30	+36	swift, short paths.
1876 October 15	31	+37	swift.
1877 November 9	29	+37	slowish.
1885 December 4	31	+37	very slow, trains.

Here we see the same coincidences of position, but there is a tendency in the later showers to yield slower meteors. In July and August they are swift and often generate streaks, but the meteors from this radiant early in December are very slow and evolve trains of sparks. It is almost certain that different systems give rise (in this instance) to the recurring radiant, though how is it possible to explain their close agreements of position?

IV. NEAR GAMMA PEGASI.

EPOCH.	RADIANT. R. A.	RADIANT. Dec.	VELOCITY.
1885 July 13	6°	+11	very swift, streaks.
1878 July 31	7	+11	very swift, streaks.
1885 August 20	5	+12	slowish.
1879 August 22	5	+17	slow (radiant estimated.)
1884 August 25	5	+10	slow, bright and short.
1885 September 15	5	+11½	slow.
1884 September 22	7	+10	slow, short.

This radiant in July furnishes very swift meteors, but during the two ensuing months I have invariably registered them as slow. The place of radiation is, however, well-defined and closely accordant. Position on August 22, 1879, evidently 6° too far north.

V. NEAR ALPHA ARIETIS.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1878 July 30	31°	+18°	swift, streaks.
1877 August 12	31	+18	swift, streaks.
1879 September 21	31	+19	slow, trains.
1885 October 7	31	+18	slow, bright.
1874 October 18	34	+18	swift, bright.
1877 November 7	30	+16	swift.

In this case the observed velocities are variable though the radiant reappears from nearly the same point during several months.

Speaking generally of these five showers I may say I have observed them on many other dates to those indicated, but the paths secured were too far to give certain radiants. With every increase of observations the same points became determinable, on additional nights, so that the epochs quoted are to be considered as representing those only whereon they have already been noticed to the best advantage. I believe that with greatly extended observation these showers will be discovered to be continuous, though sometimes affected by curious lulls and occasionally by conspicuous outbursts.

I have recorded several thousands of meteors in the region of *Perseus* and surrounding constellations and two of the best permanent radiants are near μ and ε *Persei*. Again and again I see meteors falling from the points 60.°5 +48.°4 and 61.°3 +36.°8, which are the average places of the showers I and II in the foregoing summary. I have never discovered a single radiant lying about midway between the two. In regard to the system marked III it is strange the meteors always come from the same point, 2° north of β *Trianguli*. There are no showers closely southeast or west of that star. The same persistency is found in the two remaining instances (IV and V) where the paths invariably converge upon points 5° southeast of γ *Pegasi* and 5° south of α *Arietis*, respectively, and never from the region near.

In selecting these positions as examples, I have purposely

given several which supply meteors apparently moving slower as the radiant recedes from the apex of the *Earth's* way, though such meteors are calculated to uphold the theory of parabolic motion. I might readily have quoted only those instances in which the radiants yield very swift meteors at every successive display, but I have no desire to prejudice the question by giving undue prominence to materials which are not fairly representative of the true state of things. I have also omitted for the present the positions of showers deduced by me from the observations of continental astronomers, because a man can only place implicit confidence on what he has seen with his own eyes. As to the radiant near ε *Persei* I have only quoted my observations from August 21 to September 21 and my intention is to thoroughly investigate the display during that period, for if it can be conclusively proved that the radiant point is continuous and stationary for thirty-one days, there is no reason why it may not present the same aspect during a much longer interval. To re-examine the whole matter would require an immense amount of assiduous labor; it becomes therefore necessary to narrow it down by selecting certain well-defined instances for close and critical study.

I contend there is some important meaning in this observed clustering together of radiant points. If existing ideas fail to explain it some others must be adopted that will; for theoretical objections cannot absolutely and finally negative a demonstrated fact of observation. In the present instance I do not assume the evidence amounts to demonstration, but believe a fair case has been made out for future investigation. The question ought to be thoroughly examined observationally. Hitherto the opposition has been solely geometrical. No one, so far as I have learned, has watched the sky for a single hour to test the validity and accuracy of the results brought forward. Yet it is only by patient scrutiny of the heavens that the matter can be settled, because everything depends upon the degree of reliance to be placed on recent observations. The mathematical difficulties in the way of accepting stationary radiant points are ample, and it would appear insurmountable. They have been clearly expounded on several occasions by those

well qualified to speak with authority. But, notwithstanding this apparent antagonism of observation and theory, the observed facts have not been controverted and still possess considerable significance. They will doubtless be elucidated by future observers who will obtain more complete and exact materials than any hitherto recorded. If fixed radiation is a false effect, further observations are capable of showing it in that character, but if it is a real feature then the most elaborate arguments, or refined mathematical objections, cannot obliterate it from the sky.

ON PERSONAL ERRORS IN DOUBLE-STAR OBSERVATIONS.

H. C. WILSON, CINCINNATI OBSERVATORY.

For the Messenger.

The measurement of the position angle and distance of the components of a double-star is, apparently, a very simple operation, yet it requires great care and practice to render this simple operation free from the effects of systematic errors. Neglect of the proper precautions to detect and avoid such errors has doubtless rendered the measures of the majority of double-star observers almost entirely worthless as data for computing the orbits of binaries. Accidental errors and mistakes are of little consequence, for their effects may be easily eliminated by the method of least squares, but where the errors follow regular laws this method is of no use.

Instrumental errors may be eliminated by proper methods of observing. The general rule applying to such may be stated as follows; in each measure move the parts of the instrument employed alternately in opposite directions, so that an error in one direction shall be balanced by an equal error in the opposite direction. To illustrate this rule let us refer to the diagrams, figure 1 and figure 2. In figure 1 let the parallel lines *a b* represent the threads or wires of a filar micrometer when placed in the true direction of the lines joining the centers of the stars. Now suppose the micrometer to be turned out of

this position several degrees in either direction, say toward 90°, and to be brought back slowly. The wires will appear to be parallel to the stars too soon, and the reading of the micrometer will be taken at *a′ b′*. Similarly, if the wires be brought up in the opposite direction, the reading will be taken *a″ b″*. The position angle *a′ b′* will be too large and *a″ b″* will be too small.

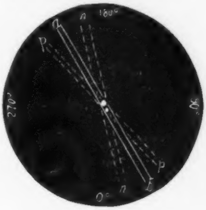


Fig. 1.

Fig. 2.

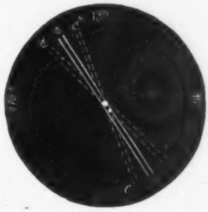


Fig. 3.

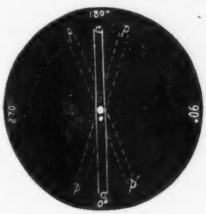


Fig. 4.

Fig. 5.

The mean of the two will be nearly correct. If an observer is in the habit of turning the micrometer in only one direction his position angles will always be too great or too small. The deviation will be systematic, varying with the distance between the stars and perhaps also with the angle.

In the measurement of distance an error in the bisection *a′ b′*

(fig. 2) when the wires are brought toward each other will be offset by an equal error of the opposite sign when the bisection is made by separating the wires, *a″ b″*. The usual method is to measure the double distance by moving one of the micrometer wires past the other, making a bisection in the same direction on each side. At the Cincinnati observatory the practice has been to measure two double distances with opposite motion of the screws.

It is not so easy to dispose of errors which are purely personal or optical in their nature, for their causes and the laws which govern them are unknown. The existence of such errors admits of no doubt, for if we compare the measures made by the most eminent observers we shall find striking differences even where the stars exhibit no signs of change. The renowned English astronomer DAWES, soon after he began to measure double-stars in 1830, discovered a tendency in his own eye to "obtain a different result in position when the line joining the centres of the stars was nearly parallel to the line joining the centres of the eyes, from that which was obtained when these lines were nearly perpendicular to each other; and a still more decided difference was found to prevail when those lines formed a very oblique angle." He sought to overcome the difficulty by attaching a prism to the eyepiece between it and the eye. By this means the stars could be placed at any desired angle. He confined himself however to the vertical and horizontal positions. It has been objected to this method that the use of the prism would cause loss of light and impaired definition and might thereby introduce serious errors of a different sort; but DAWES, after using it for forty years, regarded the objections as unfounded. I am not aware, however, of any other observer who has made regular use of the prism.

The great double-star observers, W. STRUVE and DEMBOWSKI, also recognized the possibility of such errors in their measures. They always observed with the head vertical. W. STRUVE, by means of observations of artificial double-stars convinced him-

self that his constant errors were insignificant. O. STRUVE, the son of the last named astronomer, has given in the Pulkowa Observations, Vol. IX, a most complete investigation of his own large systematic errors,as derived from a great number of observations of artificial doubles. He has also investigated the deviations of several other observers by comparison of their observations with his own corrected results. He confirms his father's conclusion in regard to the angles, but shows that his father's distances were subject to large deviations. The same was found to be true concerning the measures of DEMBOWSKI. No observer was found to be entirely free from systematic errors.

The results obtained by the method of artificial doubles have not, however, been received with entire confidence by other astronomers. The chief objection to the method is that the circumstances under which terrestial and celestial observations are made are very different; especially the circumstance that in the case of an artificial double the telescope is at rest and the stars may be bisected separately, while in observing actual doubles it is necessary to keep the eye upon both stars at the same time, because of irregularity in the motion of the telescope.

DEMBOWSKI, a short time before his death, proposed to test his personal errors by observing a number of circumpolar doubles at different distances from the meridian. He prepared a list of twenty-four stars, having no sensible motion, which he proposed to observe, on an average, five times each in each of the twenty-four hours of star time. Thus each star would be observed throughout the whole 360° of angle with the vertical. This method is undoubtedly the best which has been proposed, but involves such an amount of additional labor, especially where the regular work of the observer is in the opposite part of the sky and the dome is difficult to manage, that very few would be able to use it. According to a statement by Dr. DOBERCK (*The Observatory*, Vol. II, page 217) the astronomers, STRUVE, DUNER, HALL and WINNECKE were to join DEMBOWSKI in his investigation. Whether any of them has carried out the plan to any extent I have not been able to learn.

At Cincinnati the observers under Professor STONE's direction always inclined the head so that the line joining the eyes should be either normal or parallel to the line joining the centers of the stars. Professor STONE has given a careful investigation of the results obtained by this method in the introduction to No. 5 of the Publications of the Cincinnati Observatory. This method probably eliminates one cause of error, viz.: the oblique angle between the stars and the line joining the eyes, but introduces another, quite as serious, depending upon the inclination of the head. At the same time it furnishes the means of determining the amount of the deviation, produced by this cause, directly from the observations. This is true at least concerning the angles. In regard to the distances I am not so sure.

Suppose the line joining the centers of the stars to make an angle of about 45° with the vertical as in fig. 3. The true direction of the wires when placed parallel to the line joining the stars will be *a b*. For the normal measure of position angle, the head must be inclined 45° to the left. To do this requires an effort and causes an unequal strain upon the muscles of the neck which is perhaps communicated to the muscles that control the eye. The result is the eyes seem to be normal to the stars too soon and the wires will be set at *n n*. For the parallel measure the head is inclined 45° to the right and a similar effect is produced but in the opposite direction. As the inclination of the head is the same in both cases the amount of the deviation should be the same in each direction and the mean of the two measures should give the true angle. Again, suppose the angle with the vertical to be 0° as in fig. 4. For the normal measure the head is in the natural position, and there seems to be no reason why the measured direction should not coincide with the true direction *ab*, if the wires be brought up alternately from both sides. In the parallel measure, however, one can easily see that a very large deviation may be produced by the great inclination of the head, and that the deviation

will be plus (pp), or minus ($p'p'$), according as the head is turned to the right or left. If readings are taken with the head inclined in both directions the difference will give twice the error.

(*To be Continued.*)

OBSERVATIONS AT WILLET'S POINT.

ALICE MAXWELL LAMB, WASHBURN OBSERVATORY.

The results of the astronomical observations taken in 1885 at the field observatory at Willet's Point are announced in the Printed Orders No. 3, dated February 15, 1886. The observations for latitude with the Wurdemann and Lingke instruments were continued during 1885, as in former years, with the following results:

Wurdemann (371 observations on 81 pairs)	Lat.	40°	47′	21.″35
Lingke (193 observations on 61 pairs)	Lat.	40	47	21. 75
Grand mean giving observations and instruments equal weight	Lat.	40	47	21. 49

The following table gives the results for the various years:

Transferred from old observatory	Lat.	40°	47′	21.″70
In 1880 (326 observations on 84 pairs)	Lat.	40	47	21. 59
In 1881 (591 " " 104 ")	Lat.	40	47	21. 47
In 1882 (235 " " 60 ")	Lat.	40	47	21. 37
In 1883 (497 " " 118 ")	Lat.	40	47	21. 15
In 1884 (523 " " 89 ")	Lat.	40	47	20. 75
In 1885 (564 " " 85 ")	Lat.	40	47	21. 49

As will be seen, the sequence of the results of the years, 1880–4 which seemed to indicate a systematic change of latitude, is interrupted by the result for 1885, this result being practically the same as that for 1881.

Out of curiosity, and at the suggestion of Professor HOLDEN, I have combined the 1885 observations of the well determined pairs of stars (those designated as AA and AA, AA and A,

AA and B, A and A, or A and B) and found the mean of the results of the observations of such stars for each instrument. The mean results thus obtained are as follows:

Wurdemann (163 observations on 38 pairs)............Lat. 40° 47′ 22.″00
Lingke (80 observations on 30 pairs)...................Lat. 40 47 21. 51

No one pair of stars was observed consecutively in each of the years 1880–1885, and it is thus impossible to completely summarize the results by pairs as well as by instruments and years. The same pairs were observed, however, to some extent at least, in the years 1880-1884. The following tables show the relation between the results of observations of well determined stars in the different years. The results for the first five years were taken from the SIDEREAL MESSENGER for July, 1885,

TABLE I.

Summary of Observations of Well Determined Stars with the Wurdemann Instrument in the Years 1880, 1881, 1882, 1883, 1884, 1885.

Year.	Seconds of Latitude.	Residuals.
1880	21.37 [14]	−0.″29
1881	21.77 [20]	+0. 11
1882	21.64 [28]	−0. 02
1883	21.37 [34]	−0. 29
1884	19.76 [22]	−1. 90
1885	22.00 [163]	+0. 34
Weighted mean of the above results............		........21. 66

TABLE II.

Summary of Observations of Well Determined Stars with the Lingke Instrument in the Years 1881, 1883, 1884, 1885.

Year.	Seconds of Latitude.	Residuals.
1881	21.31 [25]	+0.″03
1883	21.29 [71]	+0. 01
1884	20.99 [65]	−0. 29
1885	21.51 [80]	+0. 23
Weighted mean of the above results............		........21. 28

The evidence of the tables seems to be rather against a systematic change of latitude at Willet's Point, but the results of future years will be awaited with interest.

April 26, 1886.

EDITORIAL NOTES.

So many valuable communications are already in hand that a number of the MESSENGER will be published for July.

Carleton College Observatory has recently received a new spectroscope made by Messrs. FAUTH & Co., of Washington, D. C. It has a Rowland grating, ruled by BRASHEAR and is adapted to the CLARKE Equatorial.

The Vanderbilt University Observatory, Nashville, Tennessee, has secured one of WARNER & SWASEY'S fine chronographs after their new pattern.

COMET 1882 II.—From the observations of the Great Comet of 1882, given on page 198 of the "Washington Observations for 1882" (just issued) it appears that the constant correction required to the transit circle north polar distances which were published in Appendix I for 1880 (page 34) amounts to $+1.''7$. This is the correction "$\triangle\varphi+\triangle z$" referred to in the appendix mentioned, and applies to the 1882 observations only. W. C. W.

COMET DISCOVERIES.—The exact date of the discovery of Mr. BROOK'S two comets of this year (as announced in *Science Observer Circular* 66) is rendered uncertain, in the transmission (apparently) of the news from Rochester to the Harvard College Observatory. A similar trouble occurred last year, and it seems to be a source of needless inconvenience to those who are trying to keep a list of new comets. The actual date of discovery should be specifically stated in the telegram. W. C. W.

COMET BARNARD.—This comet was observed here on the morning of May 17. It was low in the smoke of the city, and the moon was full, but the comet was pretty bright in the telescope. The tail was faintly suspected, pointing slightly north of following. There was an ill-defined hazy nucleus.

E. E. BARNARD.

VANDERBILT UNIVERSITY OBSERVATORY, May 18.

OBSERVATIONS OF THE COMPANION OF SIRIUS. At the request of Professor YOUNG I send you the measures of the companion of *Sirius*, which have been made at Princeton during the past three years. All except "*i*" were made by Professor YOUNG, "*i*" was made by Mr. MCNEILL. Observations "*e*" and "*f*" were made with the 9½-inch glass. All the others were made with the 23-inch. The magnifying power used was 460 in most cases, 790 was used once, and 300 several times. During the present year the companion has been quite a difficult object except when the seeing was good, and there have been fewer good nights than usual.

	Date.	Position Angle.	Number.	Distance.	Number.
a	1883.105	39.°0	3	9.″41	3
b	1884.245	37. 4	4	8. 88	4
c	1884.267	35. 7	6	8. 75	12
d	1884.280	38. 0	5	8. 92	10
e	1884.286	35. 1	5		
f	1884.286	35. 3	5	8. 26	6

Mean position angle 1884.273, 36.°30.

Mean distance 1884.270, 8.″70.

	Date.	Position Angle.	Number.	Distance.	Number.
g	1884.929	34. 9	4	[8. 62]	4
h	1884.929			7. 97	4
i	1884.929			8. 01	4
k	1884.932	35. 1	4	8. 19	8
l	1885.031	33. 6	10	8. 07	8
m	1885.201	33. 9	6	8. 01	8
n	1885.225	33. 8	5	8. 11	8
o	1885.231	33. 5	6	8. 22	8
p	1885.234	33. 6	6	8. 14	8

Mean position angle 1885.112, 34.°06.

Mean distance 1885.089, 8.″09.

	Date.	Position Angle.	Number.	Distance.	Number.
q	1886.036	30. 7	5	7. 77	8
r	1886.039	30. 7	6	7. 46	10
s	1886.042	27. 4	3		
t	1886.072	30. 3	6	7. 54	8

Mean position angle 1886.047, 29.°77.

Mean distance 1886.049, 7.″59.

MALCOLM MCNEILL,

PRINCETON, N. J., May 11, 1886. Asst. Prof. Astronomy.

THE RED-SPOT ON JUPITER.—In the April number of the *Observatory*, Mr. DENNING calls attention to the fact that the red-spot is now connected with a belt on the south side, and expresses a hope that Mr. PRITCHETT and myself will be able to see it.

Some two years since I incurred criticism from Mr. DENNING, for asserting, that it was entirely erroneous, that the red-spot had become "merged into a belt."

Subsequently, in connection with this subject, the relative seeing qualities of large and small telescopes, was pretty thoroughly discussed by prominent astronomers. It seems hardly worth while to continue the discussion, but perhaps a few remarks may not be out of place.

During the month of April of the present year, the belt to the south, approached very close to the red-spot on *Jupiter*, so that with a low power or indifferent seeing, one might imagine that the spot was joined to the belt, but when the seeing was favorable, with a power of 300 or upwards, it was seen to be separated by a narrow line of light, so that the outline of the spot was sharp and well-defined. In other words, it did not touch the spot at any point. In this connection Mr. DENNING speaks of using powers of 200 and 300. I think most observers will agree with me that this is not sufficient optical power to settle any disputed point.

In my work on *Jupiter* I never use so low a power as 200, because it is not sufficient to show detail. When the seeing is so bad that 300 cannot be used, I consider the observations of no value.

In the January number of *Monthly Notices* Mr. DENNING has given sketches of the red-spot, for different years. On February 6, 1884, he has a belt hooked on the following end of the red spot, and on February 25, 1885, he has a belt hooked on the preceding end of the spot. At the present time I presume the junction would be on the whole south side of the spot.

From 1879 to the present time, I have never observed any actual connection of the spot with the belts in its proximity.

In 1884, I stated that the spot was never "merged into a

belt," and might have added that it was always separated by a visible space. I was under the impression that in this statement I had clearly intimated, that small telescopes did not possess sufficient optical power to show the separation. In view of this fact it is rather refreshing to hear the owners of small telescopes assert that the Chicago telescope failed to show what was readily seen with the smaller ones.

They might with equal propriety assert that the inner satellite of *Uranus*, or numerous double-stars do not exist, because they are unable to see them.

In the study of planetary markings, light and separating power are just as essential as in double-star work.

In the recent discussion on telescopes, the assertion was made again and again, that large apertures give too much light for planetary observation.

My experience with various telescopes, having apertures of four inches and upwards, leads me to the contrary opinion that we do not have light enough, especially when high magnifying powers are used. I have frequently reduced the aperture of the Chicago telescope, when observing *Jupiter*, and always found I could see more and better with the full aperture.

Some recent writers appear to be under the impression that a 6 to 10-inch object glass is the best telescope. Possibly this idea was correct half a century ago, but it is not true now. There has been just as much improvement, in recent years, in the optical performance of telescopes as in any other department of instrumental astronomy. G. W. HOUGH.

JUPITER.—*Black Transit of Satellite IV.* The fourth satellite of *Jupiter* was observed in black transit here with the 6-inch on May 8th. It was first noticed as a black spot at 9*h* 20*m*, Nashville M. T. Some little time previous to this it had been looked for on the disc, but could not be seen either as a white or dark spot. 9*h* 25*m* IV still black and about in conjunction, small, seeing poor. 9*h* 32*m* still black and past conjunction. 9*h* 43*m* IV is very black and rather small and round when best seen. The satellite was not followed after this last observation. E. E. BARNARD.

COMETS *a* AND *b* 1886 (BROOKS).—On the evening of April 27, 1886, while sweeping the northern heavens with the 9-inch reflector, I discovered a nebulous object near the star *Kuppa Cassiopeia*, which I immediately decided must be a comet. Only a short time was required to detect motion, which proved to be nearly southeast; and telegraphic announcement of the discovery was made to Dr. SWIFT within two hours, who ordered it immediately cabled to Europe. The comet is large, nearly round and with slight central condensation.

Again, on the Saturday morning following, or May 1, while sweeping the eastern heavens, it was my privilege to discover another comet. It was situated in the great square of *Pegasus*, or in approximate R. A. 23 hours; declination north 21 degrees; with a northerly motion.

BROOKS' COMET NO. 2, 1886. TELESCOPIC VIEW (ERECTED) MAY 7th, 1886. POWER 100 DIAMETERS.

It has a small, but bright star-like head, and a conspicuous tail, presenting a fine telescopic appearance. It very much resembles DONATI's great comet of 1858 when telescopic. I send herewith a drawing of its appearance on the morning of May 7, my latest observation. WILLIAM R. BROOKS.

RED HOUSE OBSERVATORY, PHELPS, N. Y., May 9, 1886.

COMET *a* 1886 (BROOKS).—The following elements and ephemeris of Comet *a*, were computed by H. V. EGBERT, assistant at Dudley Observatory, and published in *Science Observer*, Nos. 67 and 68:

ELEMENTS. (Comet *a* 1886.)

$T =$ June 7.79, Greenwich M. T.

$$\left.\begin{aligned} \pi - \Omega &= 199^\circ\ 30' \\ \Omega &= 193\ \ 35 \\ i &= \ 87\ \ 53 \end{aligned}\right\} \text{Mean Equinox 1886.0}$$

$q = 0.2849$ Motion direct.

These elements represent the places used, as follows:

$\Delta\lambda\cos\beta$	$+0.'03$	$-0.'05$	$-0.''05$
$\Delta\beta$	$+\ .\ 10$	$-0.\ 13$	$-0.\ 02$

EPHEMERIS.

Greenwich 12 h. 1886.	R. A. h m s	Dec. ° ′	Light.
May 27	3 15 10	+36 00	6.6
June 24	6 52	− 4 56	4.7
July 2	7 55	− 9 24	2.2
July 10	8 49	−11 50	1.2

Light on April 29 taken as unity.

This new comet was discovered by Professor BROOKS, April 28, in *Cassiopeia*. Mr. BARNARD, of Nashville, observed it the same day, finding it "gradually a very little brighter at the center" of the nebulosity, and, in general, having the usual appearance of small telescopic comets. Its path has been southeast through *Cassiopeia*, and the 27th of May it will be among the small stars of *Pegasus*, about five degrees southeast of β, if Mr. EGBERTS ephemeris is followed. This is the day of its greatest brightness. The time of observation will be short because of its unfavorable position.

CORRRCTIONS IN S. M. No. 45.—On page 157, of S. M. for May, in the Nashville mean time of the observations of the position angle of the tail of FABRY's comet, for 4*h*, etc., read 16*h*, etc., which will make the astronomical mean time agree with the dates of the month as given in column first. I had inadvertently omitted to *add* 12*h* to the reading of my watch in the observations. E. E. BARNARD.

COMET b 1886 (BROOKS).—The elements and ephemeris of Comet b, as computed by Professor FRISBY, Naval Observatory, Washington, D. C.:

ELEMENTS. (Comet b, 1886.)

$$T = \text{May } 4.540, \text{ Greenwich M. T.}$$

$$\left.\begin{aligned} \pi - \Omega &= 38^\circ\ 45.'5 \\ \Omega &= 287\ \ 57.\ 2 \\ i &= 100\ \ 57.\ 4 \end{aligned}\right\}\ \text{App. Equinox.}$$

$$\log. q = 9.92551.$$

EPHEMERIS.

Gr. Midnight.	R. A.	Dec.	Log. r.	Log. Δ	Light.
	h m s	° ′			
May 30	3 32 58	71 9.5	9.9866	0.0905	.49
June 3	4 41 53	71 31.8	0.0032	0.1193	.40
7	5 39 24	70 35.1	0.0204	0.1478	.32
11	6 23 20	69 15.0	0.0380	0.1783	.26
15	6 58 55	66 54.1	0.0557	0.2015	.21
19	7 27 41	64 28.3	0.0734	0.2275	.17
23	7 39 51	62 58.9	0.0909	0.2486	.14
27	7 59 37	60 49.5	0.1081	0.2704	.12
July 1	8 12 33	59 4.3	0.1250	0.2910	.11
5	8 23 24	+57 23.6	0.1414	0.3096	0.10

Light May 2=1

"On May 1, the comet as observed at Cambridge had a nucleus about as bright as an 8½ mag. star with a tail from six to eight minutes of arc in length."

The second new comet of this year, was also discovered by Mr. BROOKS May 1, in the constellation of *Pegasus.* May 2 and the following morning it was seen by Mr. BARNARD who says, "it was a beautiful object, a perfect minature of a great comet. The head was very narrow and bright, and the tail was about one-fourth of a degree long and spread out towards the end. The comet's motion was very rapid to the northeast."

Professor Boss, of Dudley Observatory, also computed the elements of the orbit of this comet which agree closely with those given above. This is noteworthy, because there are special difficulties in computing an orbit so related to the ecliptic.

The comet will continue to grow fainter during this month.

o CETI AND χ CYGNI.—In confirmation of a note, relative to the latest maximum of o *Ceti*, by Mr. E. F. SAWYER (S. M. 45, p. 156) I send you the following statement from a private letter of Prof. SCHOENFELD. "The star o *Ceti* was last winter hardly one and one-half or two steps brighter than in 1868, and remained fainter than in 1867." If we consider that the deviation between ARGELANDER's elements of the maxima and the best observations may amount to twenty-five days, the close agreement of Mr. SAWYER's observation with the ephemeris is remarkable.

The epoch of maximum of χ *Cygni*, as given in SCHOENFELD's II Catalogue, viz.: 0.311, has been suspected of being a misprint, especially as the I Catalogue puts the epoch on August 25, 1863. However, Prof. SCHOENFELD informs me, that epoch in his II Catalogue means really 1800, March 11. In fact, his intention was to have the epoch near the middle of all the observations, not only for this star, but for all the rest, except o *Ceti*. I. G. H.

THE WARNER ASTRONOMICAL PRIZES.—It is a gratifying fact that very many astronomical discoveries, and some of great importance, have been made during the past few years. I think this is due in part to the impetus given by competition for the honors and prizes awarded to discoverers, and in order that this interest may to that extent be continued and sustained, I offer *one hundred dollars* for each and every discovery of a new comet made in any part of the world from March 1, 1886, to March 1, 1887, subject to the following conditions:

1. It may be discovered either by the naked eye or telescope, but it must be unexpected, except as to the comet of 1815, which is expected to reappear this year or next.

2. The discoverer, if residing in the United States, Canada or Mexico, must send a *prepaid telegram immediately* to Dr. LEWIS SWIFT, Director of Warner Observatory, Rochester, N. Y., giving the time of the discovery, the position and direction of

motion with sufficient exactness, if possible, to enable at least one other observer to find it.

3. This intelligence *must not be communicated to any other party or parties*, either by letter, telegraph or otherwise, until such time as a *telegraphic acknowledgement has been received by the discoverer from Dr. Swift.* Great care should be observed regarding this condition, as it is essential to the proper transmission of the discovery, with the name of the discoverer, to the various parts of the world, which will be immediately made by Dr. SWIFT.

Three disinterested scientists will be selected to settle any dispute that may arise regarding comet discoveries. H. H. WARNER.

ROCHESTER, N. Y., March 1 1886.

OBSERVATIONS OF BARNARD'S COMET.—

April 19 7:50 P. M. Last sight of the comet in evening.

April 22 4:20 A. M. First sight in morning.

May 3 3:30 A. M. Comet brighter, shows no tail, no stellar nucleus.

May 5 3:30 A. M. Looks like another comet, nucleus stellar, equals 5.5 mag., with tail one degree long and slightly concave on the preceding side.

May 9 3:45 A. M. Comet has larger nucleus as if a disc 5 magnitude; can just be seen with the naked eye; tail two degrees long, and slightly concave on the preceding side.

May 11. Not so brilliant at nucleus; tail traceable only one degree; very little curved. J. R. H.

OBSERVATIONS OF FABRY'S COMET.—

1886 April 1 4 A. M. (75°M. T.). Clear after a week of clouds. Comet Fabry is very bright; has a tail one degree long, is straight and brighter along the preceding edge. Just visible to the naked eye. Its color very white.

April 2 4 A. M. Nucleus probably brighter, and certainly seen by the naked eye. Tail one and one-half degrees long, with preceding edge best diffused.

April 8 4: 10 A. M. Tail generally broader and seems to taper toward the end; preceding edge clearly defined. Color less white than April 1.

April 22 4 A. M. Comet still has stellar nucleus equal to 5 magnitude; tail broad and traceable thirty minutes. Considerable coma, apparently increased in amount towards the *Sun*. Similar appearance seen April 20. J. R. H.

COMET BARNARD.—To observers in northern latitudes, as predicted last month, the comets Fabry and Barnard have not been as conspicuous objects as the computers promised. Their apparent paths were near that of the *Sun*, and their height above the horizon at night unfavorably small.

Under date of May 13, Mr. BARNARD writes of his comet as follows:

The comet discovered here on December 3, 1885, has been an interesting object in the early mornings of late. On May 8th (A. M.) it could be seen as a hazy ill-defined spot with the naked eye. Unfortunately the comet in the morning has been just over the smoky city and consequently has always been seen at a disadvantage; a nucleus shone in the head, but it was not stellar, the image unsteady however, which may have caused the ill-defined appearance. The tail was long and bright, stretching for a considerable distance out of the field of view; it was brighter along the following side, and broader than at former observations.

May 13 (A. M.) The comet seen through heavy smoke over city; it was dimly visible to the unaided eye, the very low altitude and the thickness of the sky prevented any good observation of it. In the 6-inch the comet was bright and a bright hazy nucleus was visible in the head. The tail was broader than formerly.

MEASURED POSITION ANGLES OF THE COMET'S TAIL.

May 7....	Nashville M. T. 15*h* 32.*m*9....	P. A. of Tail	317.°66....	3 obs.
" 12....	" " 15 25. 7....	" " "	329. 91....	1 "

COMET BARNARD (*a*) 1885.—The remarks of Prof. SWIFT and of Mr. LEAVENWORTH lead me to give my last observations of this comet.

August 28, with Mr. EGBERT's ephemeris I picked up the comet which was seen with some difficulty in the 6-inch. It was close south preceding a 9th-magnitude star.

August 31 positive of seeing it, but very faint, it was 8′ or 10′ north preceding a 10th mag. star. Seeing not specially good. After this date poor skies prevented further search for the comet.

Comet Barnard 1884. My last observations of this comet were 1884, November 5, 6, 7, 8, 9, 10, 11 and I feel sure that it could have been followed longer had good skies continued. It was very faint in the five inch on these dates. E. E. BARNARD.

VANDERBILT UNIVERSITY, April 5, 1886.

The following orders and subscriptions have not been previously acknowledged:—

Normal School, Ypsilanti, Mich. Jennie Leys, Los Angelos, California. John L. Bennett, Galena, Ills. (Vol. 4). Professor Charles A. Bacon, Director Smith Observatory, Beloit College, Wis. Professor T. C. George, Natural Sciences, University of the Pacific, San Jose, Cal. Librarian of Baldwin University and German Wallace College, Berea, Ohio. Jas. S. Lawson, U. S. C. and G. Survey, Box 2512, San Francisco.

The Star-Guide: A List of the Most Remarkable Celestial Objects Visible with Small Telescopes, with their Positions for Every Tenth Day in the Year, and Other Astronomical Information. By LATIMER CLARK, F. R. A. S. and HERBERT SADLER, F. R. A. S. Publishers, Messrs. MACMILLAN & Co., London, 1886, pp. 50.

Those students of astronomy who are acquainted with "WEBB's Celestial Objects for Common Telescopes," will easily understand the purpose of this small book. It may be considered an introduction to such a work as that before named for amateurs having telescopes with apertures ranging from two to four inches.

When the student begins to observe, he does not know, if illustrated, what objects to select that are best suited to the size of his telescope that he may use his time and instrument most wisely. He ought neither to try difficult double-stars or faint nebulæ without experience, knowledge of the instrument used and self-confidence. This little book is intended as a self-help to aid the amateur in making a right start, and to guide him by the readiest path to independent work. It seems to us quite certain that a student with a small telescope and any interest in the multitude of beautiful objects of the nightly skies would not be long in awakening a quenchless ardor with such proper guidance early.

Following an introduction of ten pages, appears the list of most remarkable objects selected for amateur study. Under each month of the year are arranged about fifty objects in the order of right ascension, the first column giving the star's name; the second, the months limiting the time visible; next two, right ascension and declination; the next four, respectively, the mean time of transit at Greenwich on 1st, 11th, 21st, 28th days of the month; the next two, distance and position angle of double-stars; the next magnitudes; and the last column is for remarks. Arranged in a similar manner is a small table of circumpolar stars; a table of objects suitable for telescopes from four to seven inches aperture, numbering two hundred; and a table of twenty-four radiants of shooting stars. Then follows an interesting series of tables of test objects, containing from six to twelve each that are grouped for dividing tests, defining tests and space penetrating tests, in separate tables for telescopes of 2, 3½, 3, 3½, 4, 5, 6 and 7-inches aperture respectively. The next table gives the selenographical latitude and longitude of two hundred and twenty lunar craters and other objects, with the names of each arranged in alphabetical order, and references to WEBB's lunar map, by number and quadrant.

From what has been said of the contents of the "Star Guide" it will evidently commend itself to the attention of all amateurs as a very useful hand book and a time-saving aid in many obvious ways.

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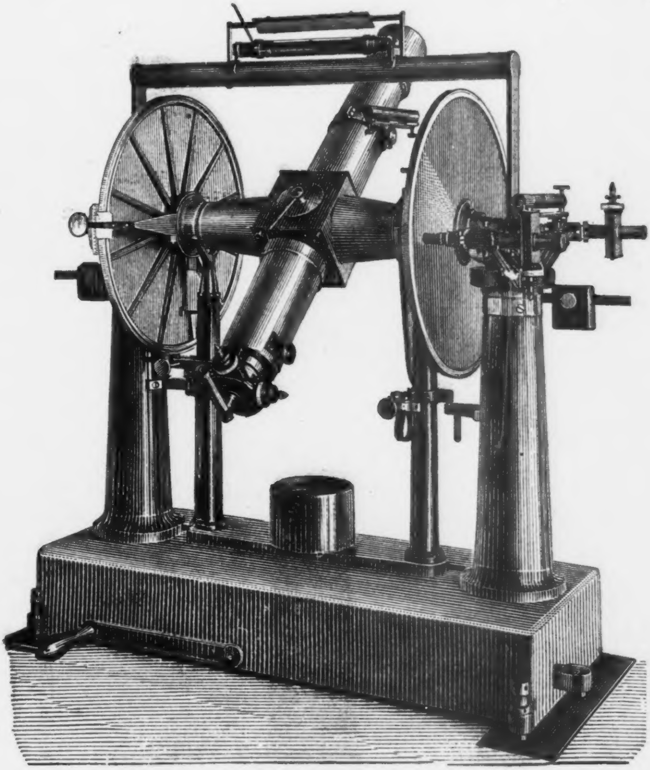

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